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SOME OF THE RESULTS OF RECENT RESEARCH ON THE CONTROL OR PREVENTION OF SILICOSIS

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BY

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

SOME OF THE RESULTS OF RECENT RESEARCH ON THE CONTROL OR PREVENTION OF SILICOSIS[1]

By D. Harrington[2]

Research in connection with occupational diseases, including silicosis or, more definitely, pneumoconiosis, has been prosecuted much more actively in North American countries during the past 5 or 10 years than in any other known period. This applies particularly to the United States, owing largely to the fact that in recent years compensation for ill health presumed to be caused by industrial work of certain kinds is being paid to a far greater extent in this country than previously. Most other countries have had occupational-disease laws for many years. Court rulings in the United States, which started 5 or 6 years ago, have given a few heavy verdicts in connection with ill health or death caused, or alleged to have been caused, by some phase of occupational work other than traumatic injury, and these have called attention to the fact that ill health and even incapacitation can be caused by some kinds of employment.

With the onset of the world-wide financial depression, which resulted in permanent abandonment of many business or industrial enterprises (among them mines) in the United States, the workers frequently believed that they could expect nothing in the future from their former employers, hence they felt free to demand monetary benefits or damages because of ill health which they suffered, or thought they suffered, because of their previous employment. The result was a flood of lawsuits and compensation claims for occupational disease, particularly where dust was involved.

This condition resulted in the gradual widening of accident compensation laws in a few States to include one or a few occupational diseases, or the passage of new laws covering occupational disease alone, until today in the United States 21 of the 48 States and the District of Columbia have occupational-disease laws or regulations. In several other States commissions or other bodies are studying such diseases with a view to the enactment of legislation.

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 6994." Presented before a joint meeting of The American Institute of Mining and Metallurgical Engineers and The Canadian Mining Institute at Vancouver, British Columbia, September 17, 1937.

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The increase in occupational-disease compensation legislation has brought out the fact that few dependable fundamental data are yet available as to occupational disease, its cause, effects, and remedies. This is particularly true of nearly all dust diseases, which are usually referred to as silicosis but which, more accurately, should be designated as pneumoconiosis or simply dust disease. The courts and lawmakers are confronted with such diversity of opinion as to fundamental facts, even from those best able through experience and observation to testify or advise, that there has arisen a real demand for dependable data. Consequently, scores (probably hundreds) of organizations, public and private, are now engaged in research work on industrial (occupational) disease, and at present probably more attention is being given dust disease than any other feature of the general subject.

In the Western Hemisphere the Bureau of Mines was a pioneer in the study of dust disease, both in the field and in the laboratory. Its various researches were begun shortly after the Bureau came into existence in 1910; it has published many of the results, and, as is usual in work of this kind prosecuted over years and with numerous individuals participating, many valuable unpublished data remain in the Bureau's files. Lack of funds greatly curtailed this activity, but in the past 3 years some of the work has been resumed and at present the Bureau is engaged, both in the laboratory and in the field, in dust-health research and investigative work of various kinds.

One of the essential features of inquiry as to the harmfulness of dust is obviously a knowledge of the degree of air dustiness or the quantity of dust in the air. The definite need for this knowledge for use in framing laws and regulations regarding dust disease has revealed that the present-day devices, methods, and procedure for determining air dustiness leave much to be desired, not only as to accuracy and dependability of results but also as to applicability to different industries or industrial conditions. The impinger equipment and method, used more or less universally in the United States but almost not at all in other countries, has numerous imperfections which apply particularly to its use in the mining and allied industries. Much Bureau of Mines research on dust has been concentrated on efforts to simplify and improve procedure for obtaining definite data as to air dustiness. This is of fundamental importance, as it is generally agreed that curative effort in connection with dust disease (or at least as to silicosis at present) affords little, if any, relief, and essentially the only "cure" is prevention. Evidently, in order to prevent air dustiness it is necessary to know definitely what constitutes air dustiness that is or may be harmful to health.

A comprehensive study has been made of the characteristics of the most used of the various available air-dust-sampling devices and methods; the study was made partly in the laboratory and partly in the field in and around mines and mining plants. Some of the results of this study were published in The Mining Congress Journal (Washington, D. C.), November 1936. The paper, entitled "Equipment and Methods for Determining Air Dustiness in Mines", was written by C. E. Brown, chemist, and gives a concise tabula-

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tion of the essential facts connected with several of the main dust sampling and determining methods and devices used not only in the United States but in other countries. It also gives considerable data on alterations of a microprojector devised by the Bureau of Mines for alleviating the burdensome and eye-tiring job of counting dust particles. A paper entitled "The Microprojector for Determining Particle Size Distribution and Number Concentration of Atmospheric Dust", by C.E. Brown and W. P. Yant, was published in October 1935 by the Bureau of Mines as Report of Investigations 3289. It gives information on the constructive use of the microprojector devised by the Bureau of Mines.

One of the major activities of the Bureau's dust research in the past few years in conjunction with its study of existing devices and methods for ascertaining air-dust determinations has been that of trying to obtain some device and method of determining air dustiness more readily applicable to mining conditions than any of those more or less generally used. As a result, what is called a midget impinger has been devised, based on essentially the same principle as the impinger apparatus more or less generally used in the United States but which has numerous features that make it cumbersome and otherwise inapplicable to mining. A paper describing this device has been prepared and is now being issued.

In the present-day devices and methods of determining air dustiness slight deviations are likely to result, owing to personal attributes or ideas of the investigator or to other causes, such as conditions found in mines which necessitate various changes in the use of dust-sampling and analytical equipment; these apparently slight deviations may invalidate the results entirely. For instance, in the impinger, variations of the liquid which entraps the dust may readily throw the dust counts completely out of line, and with certain liquids there is likely to be considerable loss of dust (even silica) unless the determinations are made within a limited time after the dust is collected. Papers are to be issued which call attention to several of these hazards and point out a more or less standard procedure for use in and around mines of some available dust-sampling devices.

The emphasis now placed on free-silica dust makes it almost imperative that a relatively simple process be made available for rapid yet reasonably accurate determinations of the free-silica content of mine-air dust; at present no such method is available, although the free-silica content can be determined by some rather tedious and costly methods. The Bureau has studied several possible methods (chemical, petrographic, and X-ray). Some progress has been made in all three of these methods, and it is expected that in a relatively short time (probably before January 1, 1938) a workable X-ray method will be devised to give our mining people quick and fairly accurate data as to the free-silica content of dust. Much care is necessary, however, as it now appears that the mineral composition of airborne dust is likely to vary materially from the composition of rock strata being worked and the dust that settles on surrounding surfaces. A paper on the X-ray and possibly on other methods of determining the free-silica content of dust will probably be issued before or not long after January 1, 1938

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The increased activities in connection with dust disease brought about a definite demand for personal protective equipment, such as respirators; and the Bureau of Mines, after several months of laboratory and other study and numerous consultations with manufacturers and others interested, prepared a schedule for testing dust respirators so that any device that would pass the tests would pass the tests would almost certainly give adequate protection to its wearer against the dust or dusts it was designed to handle; in addition, it was endeavored to have the devices so constructed that it would be practicable to wear them. This schedule was published in August 1934 as Schedule 21, "Procedure for Testing Filter-Type Dust, Fume, and Mist Respirators for Permissibility", and under the schedule 19 respirators have been approved. Bureau of Mines Information Circular 6952, issued August 1937, "List of Respiratory Protective Devices Approved by the United States Bureau of Mines", gives, among other data a list of 19 respirators approved to the date of writing the circular. Recently Schedule 19-A for approval of supplied-air respirators, entitled "Procedure for Testing Supplied-Air Respirators for Permissibility", has been approved by the Department of the Interior, and it is expected that printed copies of this schedule will be available before January 1, 1938. This schedule was difficult to formulate, and much technical study, considerable laboratory work, and innumerable consultations were held with interested parties before the final provisions of the testing procedure were adopted.

Machine drilling has long been known as one of the worst producers of air dustiness in metal-mining operations; with the elimination of dry drills by mining companies sensible of their obligations to their workers, it was felt that this particular problem had been solved. While present-day wet drilling is far superior to the dry methods of the past, it now appears that wet drilling is far less effective in reducing air dustiness than had been supposed, and the Bureau of Mines and numerous other agencies have been and are doing considerable research as to the actual harm done in wet drilling, why and how the harm is done, and how to prevent it. Studies show that in wet drilling the holes often are collared or started dry or with a minimum of water sent through the steel; sometimes this "dry collaring" extends several inches into the hole, as the worker desires to minimize the possibility of having the water splashed or sprinkled upon him. With dry collaring the surrounding air becomes dust-impregnated, and this condition may continue for long periods in the poorly ventilated places frequently found at the working faces of metal mines. It is also ascertained that under some conditions the proportion or quantity of water going through the drill steel is so little and that of compressed air so great that the so-called wet drilling is largely a misnomer; drilling is largely dry, as the compressed air is given a maximum opportunity to escape from the hole, carrying with it the greatest possible quantity of finely divided dust to go immediately into the surrounding air. Some people believe the remedy is to use wet drills which exclude compressed air from the hollow steel that carries the water, but which send the water under pressure through the hollow steel. A few of these drills are being tried in the United States; but it is believed that while they may be made adaptable to our work in time, the ordinary types of wet drills will keep dust production well within the allowable limits provided care is taken in

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the upkeep of the drill and its use. In fact, this is being done in several mines where the mining officials are sufficiently dust-conscious to provide the right equipment and methods and to include adequate supervision designed to reduce air dustiness. It is expected that within the next few months several short papers will be published on precautions to be taken in wet drilling in mines with a view to holding the production of air dustiness to a minimum.

Use of foam and so-called wetting agents in drilling to reduce air dustiness has been and is being studied; while the results have not as yet proved very satisfactory, the idea appears to justify further studies but possibly along slightly different lines.

Some attention has been given to the use of dust traps in dry and wet drilling; they have not at present been adapted successfully to underground mining in the United States, but it may yet be found that the use of a trap in conjunction with the present-day types of wet drills used in the United States will solve the problem of preventing the air dustiness now created by wet drilling largely through careless procedure. Dust traps have a definite place in surface drilling as in quarries, and other surface rock excavations.

Studies have been made partly in operating mines and partly at the Bureau of Mines experimental tunnel at Mount Weather, Va., as to the relative quantity of dust created in drilling with sharp bits as against drilling with dull drill bits. The data obtained to date indicate that much more dust is created with sharp drill bits than with dull ones; this is decidedly surprising, and does not accord with information given out recently from foreign sources. A paper to be presented soon will give the tentative result of studies made to date on this phase of the inquiry. It may develop that other features enter into the matter and that the tentative results will be subject later to qualifications or limitations, as the dullness or sharpness of drill bits may be affected also by depth of hole, speed of drilling, quantity of water used, etc.

With dry drilling largely eliminated from progressive mines, even conceding that wet drilling gives off some dust to the air, the most definite producer of dust in present-day metal mining is blasting, and unless this source of supply is curbed efforts to prevent dust disease among miners are likely to prove futile. Field studies have been made in mines and tunnels of available feasible procedure to aid in the reduction of air dustiness from blasting. Dust counts and numerous observations were made with and without the use of mists, water blasts, wetting agents, sprinkling of walls before and after blasting, and muck piles, and air dustiness was observed at various intervals after blasting with and without water and ventilation. These and numerous factors connected with dustiness due to blasting and feasible methods of preventing or reducing it were studied. Not the least of these is blasting according to schedule and doing all possible blasting at the close of the shift or on an off shift. The supposedly harmful gases produced in blasting (CO, CO_2, oxides of nitrogen, etc.) were also studied, as there is a tendency to believe that

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these gases, even in small quantities and percentages, have a deleterious effect on health when breathes with dust. One or more papers will be issued during the fiscal year on these phases of the Bureau of Mines research into the prevention of dust disease.

Ventilation has long been known as one of the essential factors in the dilution or removal of dust from atmospheres in which men must work. With the usual metal-mining practice of driving only one tunnel or other opening instead of two or more openings, as in coal mines (which are readily adapted to the coursing of air as it enters one opening and is taken out through another), it is by no means easy to provide enough relatively fresh gas- and dust-free circulating air at the working places. Actual investigations reveal that even the best available ventilation procedure with one opening, as in the metal-mining system, is not nearly as efficient as it should be. Air-conditioning methods are now being tried in some mines, and these may, at least partly, solve the ventilation problem. Up-to-date data on these matters have been assembled, and it is expected that short papers on specific phases of the subject of ventilation and mine-air dustiness will be published during the present fiscal year.

Scores of investigations on dust disease and other phases of occupational disease are being carried forward in many, probably most, civilized countries, and it is important for those concerned in such investigations to keep in contact with published and other information on what is being accomplished. To fill this need, the Bureau keeps in close touch with world technical literature, and in 1935 and 1936 issued several publications by D. Harrington and S. J. Davenport on almost every phase of dust disease, as follows:

Information Circular 6835, March 1935, Review of Literature on Effects of Breathing Dusts, With Special Reference to Silicosis. Part I. Chapter 1 - Definition and Classification of Dusts. Chapter 2 - Sources of Exposure to Dusts. Chapter 3 - Physiological Effects of Breathing Dusts.

Information Circular 6840, May 1935, Review of Literature on Effects of Breathing Dusts, With Special Reference to Silicosis. Part II-A. Chapter 4 - Prevention of Dust Diseases (Sections 1 and 2).

Information Circular 6848, July 1935, Review of Literature on Effects of Breathing Dusts, With Special Reference to Silicosis. Part II-B. Chapter 4 - Prevention of Dust Diseases (Sections 3 - 5).

Information Circular 6857, October 1935, Review of Literature on Effects of Breathing Dusts, With Special Reference to Silicosis. Part III-A. Chapter 5 - Economic and Legal Aspects of Dust Disease in Industry (Sections 1 and 2).

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Information Circular 6892, August 1936, Review of Literature on Effects of Breathing Dusts, With Special Reference to Silicosis. Part III-B. Chapter 5 - Economic and Legal Aspects of Dust Disease in Industry (Sections 3 and 4).

These papers were issued in mimeographed form and were in great demand; approximately 5,000 copies of each were distributed, chiefly on request. In August 1935 the Bureau of Mines issued Bulletin 400, which embodied all five circulars, an index, table of contents, and extended bibliography. The Bureau expects to issue during the present fiscal year one or more papers on current literature on dust disease to bring the data in Bulletin 400 up to date.

Laboratory workers on dust research have been sent into the field to study underground conditions in mines so that laboratory research may be done with a view to its applicability to mining conditions. On the other hand, about 15 field engineers, engaged in the health and safety work of the Bureau of Mines, have been brought into the laboratory at Pittsburgh, Pa., and some of them have been detailed to work with the laboratory research men when the latter were engaged in investigations in mines. This interchange of work and information is being done so that the research work will be available for practical use. The field engineers are being supplied with dust-sampling and determining equipment and are being detailed to the study of dust in mines and plants of the mining and allied industries. It is expected that as a result of these studies numerous papers will be available as to procedure (or lack of it) in handling air dustiness in most of the mining regions of the United States, including the coal-mining region. It may be apropos to state that numerous mining companies in the United States (some of them engaged in coal mining) are now establishing dust-research organizations, and their data on air dustiness ultimately will be published.

In addition to its relatively recent research on dust disease, the Bureau of Mines has collected information in the laboratory or in mines with a view to correlating the results of various dust-sampling methods and devices, but dependable correlating curves have not as yet been obtained; in fact, there appears to be every probability that such results are unobtainable. Observations have been made as to air dustiness caused by drilling with various kinds and makes of rock drills, drill bits, and drill steel lengths and various directions (horizontal, inclined upward, inclined downward) of drill holes, also as to numerous other phases of drilling; changes in air dustiness due to passage of the air through fans, fan tubing, openings with straight and crooked walls, wet walls, dry walls, etc.; the degree to which fine dust may be eliminated by various wet methods; the technique of using dust-sampling equipment (the impinger, konimeter, etc.) in hot, cool, wet, and dry atmospheres, etc.; and the possibility of adapting certain types of laboratory equipment to use in the mine or field to simplify and possibly to eliminate much of the delay in the determination of results of analytical work.

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The Health and Safety Branch of the Bureau has been rather busily engaged during the past several years (particularly the past 3 years) in trying to obtain fundamental data on dust, with particular reference to the prevention of silicosis or pneumoconiosis, as it is now generally agreed that herein lies the real solution of the problem of alleviating the admittedly bad plight of many industrial workers in dusty atmospheres. The subject is so abstruse that many of those who have been engaged on it for 20 or more years now admit that the ideas prevalent in the past as to dust disease, its extent, causation, and possible cure, must be radically revised. About the only definite information available is that, under some conditions at least, the breathing of large quantities of dust is likely to be harmful to health; hence, if dust can be eliminated from the air, or if the dust content of very dusty places can be greatly reduced, there is good reason to expect that dust disease will either disappear or its incidence be greatly lessened.

With the firm foundation established by the studies of the past 3 or 4 years as a basis, the Bureau of Mines is now bending its energies in dust research largely on the elimination of dust from the air of mines, and it expects to be able to give considerable aid to the mining industry in the future as to suitable procedure to protect the worker and employer from serious ravages due to dust disease.

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